EFFECT OF SURFACTANTS AND FORMULATIONS ON DISTRIBUTION OF CYPERMETHRIN USED FOR SUBTERRANEAN TERMITE CONTROL IN SANDY SOIL

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Abstract—The distribution of cypermethrin (Demon®) affected by formulations and surfactants in a sandy loam soil was determined. Eight treatments consisted of Demon TC (25.3 % cypermethrin, emulsifiable concentrate) or Demon Wettable Powder (40.0% cypermethrin) with 0.25% AI concentration mixed with or without a surfactant (0.1% of Atlox 8916-TF, Tween 20 or G-3300). Each treatment was replicated three times. One control (untreated) treatment was also included. An experimental unit assigned to each treatment was a plywood box (1.83 X 1.83 X 0.6 cm) filled with sandy loam soil and covered with a 7.6 cm concrete slab. A 1.3 cm hole at the center of each slab was made by drilling through the slab. The 1.52 Liter of insecticide was applied under 172.5 KPa pressure through the concrete slab using a sub-slab injector equipped with a 10.2 cm single bored straight tip. Four soil cores measuring 93 cm in length and 2.54 cm in diameter were removed from each unit with cores 1, 2, 3 and 4 located 2.5, 15.2, 30.4 & 45.6 cm below the bottom of the concrete slab, respectively. Each core was divided into 9 soil samples (first 5 samples, 7.6 cm in length and the remaining 4 samples 15.2 cm in length). Cypermethrin from soil samples was extracted and analyzed by gas chromatography.

Data were statistically analyzed by Proc GLM:Repeated Measures Analysis. The results indicated the type of insecticide formulation did not significantly affect vertical penetration or lateral distribution. The presence of surfactants generally yielded greater lateral distribution of cypermethrin. Demon TC plus Atlox and Demon WP plus G-3300 provided the highest lateral distribution (53.2 cm) from the injection point with amounts more than the minimum of 1 µg of cypermethrin per gram of soil required for termite control. Cypermethrin applied without a surfactant yielded 30 cm of lateral distribution from injection point with amounts adequate to control subterranean termites.

INTRODUCTION

Of all structural pests, subterranean termites cause the most damage to structures in the U.S.A.. Currently registered organophosphate (OP) and pyrethroid termiticides generally provide 100% termite control for 5 years and 80-100% control for up to 10 years (Kard et al., 1989). Creation of continuous termiticide barriers in soil is a common method of protecting residential and commercial structures from subterranean termites. Generally, the continuous chemical barrier depends upon an overlapping distribution of termiticides in the soil. Studies on distribution of water soluble dyes, applied with rodding and sub-slab injection techniques, have been used to predict the distribution patterns of termiticides in soils (Brehm, 1991; Mampe, 1992). However, these data may not be indicative of actual distribution due to variations in physical and chemical properties of dyes and termiticides. The horizontal and vertical distribution of termiticides may also differ because of variations in soil properties, application pressure, insecticide formulations, surfactants and amounts used. Published data on chlorinated hydrocarbon (Bennett *et al.*, 1974) and organophosphate (Davis and Kamble, 1992; Davis and Kamble, 1993) insecticides did not measure the effect of surfactants on termiticide distribution in soils. This research was undertaken to determine the distribution characteristics of cypermethrin (Demon®) in soil affected by type of formulations and non-ionic surfactants.

MATERIAL AND METHODS

Insecticide Treatments and Soil Type. The two insecticide formulations used were: Demon TC, emulsifiable concentrate (EC), (25.3% cypermethrin) and Demon Wettable Powder (WP) (40.0% cypermethrin). The study included eight treatments (Table 1) and the experimental design was a complete randomized design. The sandy loam soil used in this research had pH 7.81, organic matter 0.15%, sand 68.08%, coarse silt 5.92%, fine silt 10.67%, very fine silt 1.18%, and clay 14.14%.

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Table 1. Treatment parameters used in determining distribution of cypermethrin in sandy loam soil.

	Treatment[a]			
Insecticide	AI +	Surfactant (0.1%)	Replications	No. of Soil Samples
1. Demon TC	0.25%	None	3	!08
2. Demon TC	0.25%	Atlox 8916-TF	3	108
3. Demon TC	0.25%	G-3300	3	108
4. Demon TC	0.25%	Tween 20	3	108
5. Demon WP	0.25%	None	3	108
6. Demon WP	0.25%	Atlox 8916-TF	3	108
7. Demon WP	0.25%	G-3300	3	108
8. Demon WP	0.25%	Tween 20	3	108
9. Control	(Untreated)		1	36
		Total	24	900

[a]Diluted insecticide quantity of 1.52 l/application point and injection pressure of 172.50 KPa were constant for all treatments.

Experimental Unit and Insecticide Application. The experimental units assigned for each treatment were plywood boxes measuring 1.83 x 1.83 x 0.6 m. Soil was added to each box in increments of 17.8 cm and packed with a hand operated tamper. The top of each successive layer was lysed with a garden rake to avoid panning effects between layers. The process was continued until each box was filled to a soil depth of 53.3 cm. The soil was compacted to ca. 1.4 g/cm^3. After filling, each box was capped with a 7.6 cm concrete slab. These conditions were selected to simulate conditions under a basement slab in a home.

A 1.27 entry hole was made by drilling through the center of the concrete slab of each box and insecticide was applied to the soil with a B&G® sub-slab injector unit equipped with a beveled, single bore, 10.2 cm long tip. A modified B&G, 11.3 l stainless steel spray tank used as an insecticide reservoir was connected to the 18.9 l stainless steel CO^2 tank to maintain constant pressure. After application, the hole was sealed with a concrete-mortar mix.

Soil Sampling Technique. Four holes (3.3 cm dia) were drilled along a vertical line bisecting one of the plywood side panels of each box. The top hole was positioned 2.5 cm beneath the bottom of concrete slab. The remaining three holes were located 15.2, 30.4, and 45.6 cm below the bottom of the slab (Fig. 1).

Four soil cores, each 0.93 m long and 2.54 cm in diameter, were removed from each box using a stainless steel soil probe. The probe was triple rinsed with acetone prior to reuse to minimize insecticide carryover between samples. Each core was subdivided into 9 separate soil samples (Fig. 1) with samples × 1 located proximal to the plywood sideboard and sample × 9 located vertical to the injection point. Each of the three soil samples of a core located nearest to the plywood side board were 15.2 cm long. The remaining six soil samples of each core were 7.6 cm long. Each sample was placed in a separate, prelabeled plastic Ziploc® bag and stored on ice in chest coolers at the field site. The samples were later taken to the laboratory and stored in a chest freezer (-20°C).

Cypermethrin Extraction and Chemical Analysis. Ten grams of soil were removed from each sample and placed in a 500 ml erlenmeyer flask. Later, 150 ml solution of histological grade acetone plus reagent grade hexane (50:50, v/v) were added to each flask. The flasks were capped with neoprene stoppers (prewrapped with plastic cling sheets), mounted on a wrist action shaker (Burrell, model #75) and agitated for 60 minutes. After agitation, the flasks were stored in a freezer (-20°C) until filtration. The soil acetone/hexane slurry in each flask was filtered through two sheets of #1 Whatman filter paper into 500 ml separatory funnels. Each erlenmeyer flask was rinsed twice with 20 ml 50:50 hexane plus acetone (v/v). The rinsates were added to the separatory funnels. After filtering, 100 ml of type 1 deionized water was added to each separatory funnel. The separatory funnels were then capped and hand agitated for 5 seconds and the lower phase was discarded after liquid partitioning had stabilized. Type 1 water (100 ml) was added again and the process was

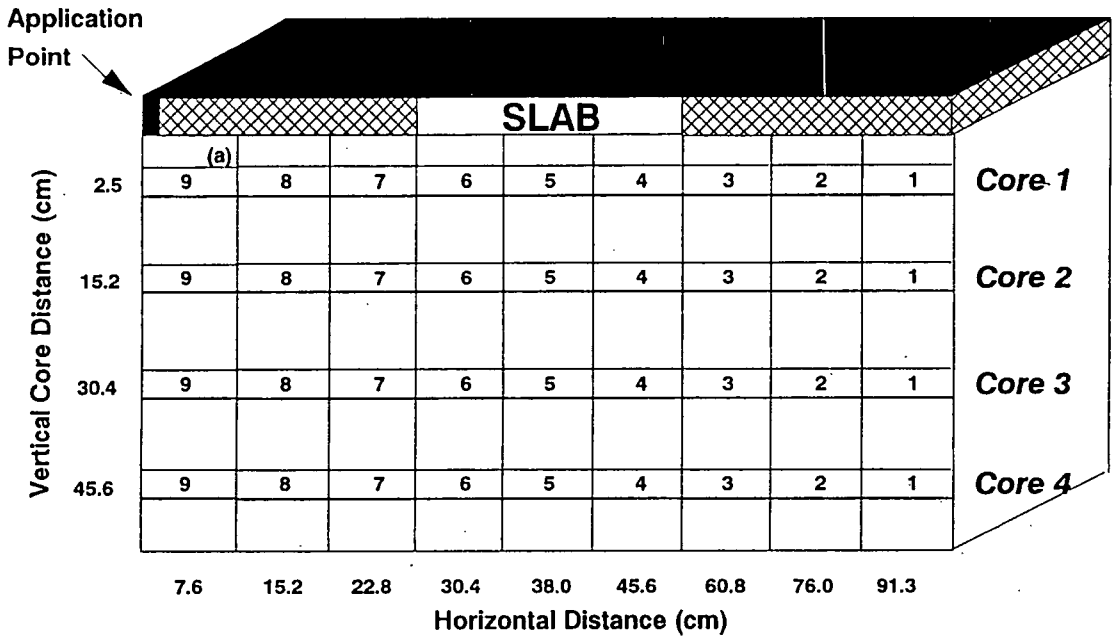

Figure 1. Cross sectional view of the sampled portion (0.25%) of each experimental unit indicating the positions of the 4 soil cores and the 36 soil samples relative to the injection point (a = soil sample number).

repeated. To remove any remaining water, 10 g of anhydrous sodium sulfate was added to each separatory funnel. After drying, the remaining liquid was drained from the separatory funnels into 250 ml boiling flasks. The funnels were rinsed twice with 10 ml ea. of reagent grade hexane. Each rinsate was decanted into the corresponding boiling flask. Each boiling flask was then mounted on a rotovapor apparatus (Buchi, model #RE111) equipped with a water bath (70°C) and the filtrate was allowed to evaporate until near dryness. The concentrated residue in each boiling flask was re-dissolved in 5 ml of hexane, decanted into a 5 ml glass syringe and transferred to a 12 ml glass storage vial. The process was repeated to allow for a total of 10 ml of concentrated residue in each storage vial. The vials were then stored in freezer (-20°C) until analysis.

Cypermethrin was analyzed with a Varian 3400 gas chromatograph (G.C.) equipped with a Varian 8000 autosampler and an electron capture detector (ECD). The column used was a 10% O.V. 101 on Chromosorb W-HP, 80/100 mesh, 2 meter glass packed column. The column was set at 200°C for 3 minutes then increased to 300°C at a rate of 10°C/min for a total run time of 19 minutes. The injector and ionization temperatures were set at 200°C and 300°C, respectively. The nitrogen and air flow rates were set at 30 and 175 ml/min, respectively. Under these conditions the elution time for the combined cypermethrin isomers was ca. 14.66 minutes. The detection limit of this process was determined to be 0.10 µg/ml. An average extraction efficiency of 79.70 ± 6.04 was used in adjusting the insecticide values for all analyzed field samples. The mean cypermethrin recovery from field fortified soil samples was 103% ± 0.18%, indicating excellent storage stability. Data were statistically analyzed by Proc General Linear Model, Repeated Measures Analysis, ANOVA (SAS Institute 1985).

RESULTS AND DISCUSSION

Based on our GC detection limit, cypermethrin was not detected in soil samples from the untreated experimental unit. The horizontal distributions of cypermethrin were significantly affected by the type of surfactant ($Pr > F = 0.0019$), core location ($Pr > F = 0.0001$) and the interaction of

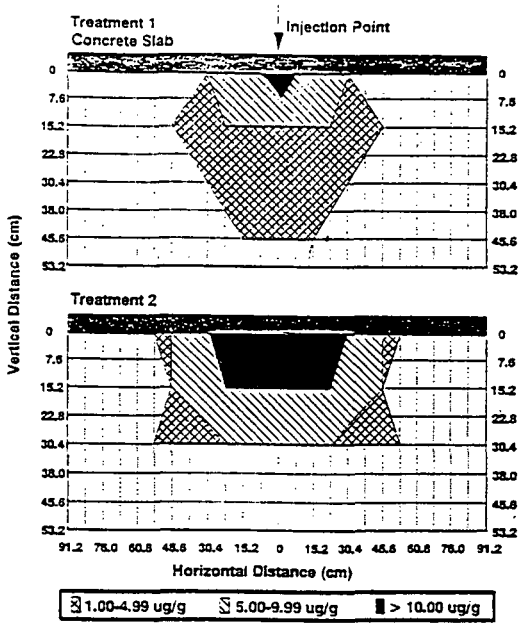

Figure 2. Distribution of Demon TC in a sandy loam soil in Treatment 1 (0.25% AI, 1.52 L, 172.5 KPa) and Treatment 2 (0.25% AI, 1.52 L, 172.5 KPa, Atlox 8916-TF (0.1%))(360 degree extrapolation).

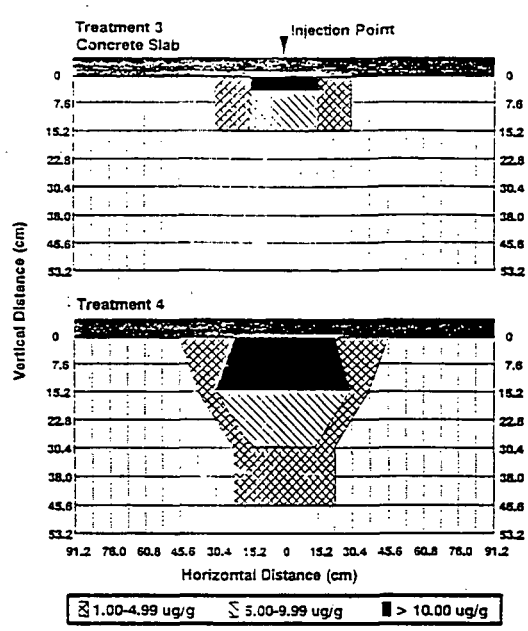

Figure 3. Distribution of Demon TC in a sandy loam soil in Treatment 3 (0.25% AI, 1.52 L, 172.5 KPa, G-3300 (0.1%)) and Treatment 4 (0.25% AI, 1.52 L, 172.5 KPa, Tween 20 (0.1%))(360 degree extrapolation).

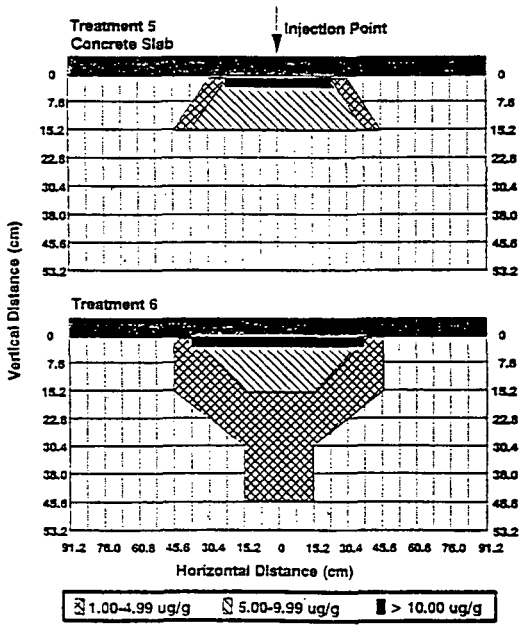

Figure 4. Distribution of Demon WP in a sandy loam soil in Treatment 5 (0.25% AI, 1.52 L, 172.5 KPa) and Treatment 6 (0.25% AI, 1.52 L, 172.5 KPa, Atlox 8916-TF (0.1%))(360 degree extrapolation).

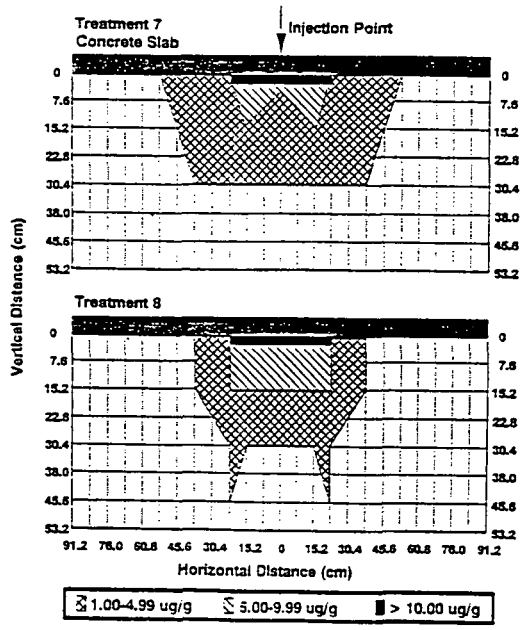

Figure 5. Distribution of Demon WP in a sandy loam soil in Treatment 7 (0.25% AI, 1.52 L, 172.5 KPa G-3300 (0.1%)) and Treatment 8 (0.25% AI, 1.52 L, 172.5 KPa, Tween 20 (0.1%))(360 degree extrapolation).

surfactant and core location (Pr>F = 0.0087). Data also indicated that the type of insecticide formulation did not significantly affect cypermethrin distribution in sandy loam soil.

Soil samples directly below the application point in core 1 of all treatments had the highest mean cypermethrin concentration. Insecticide residues adequate to control subterranean termites (> 1.0 µg of cypermethrin/g of soil; Su and Schefrahn, 1990) were detected vertically up to 15.2 cm and horizontally up to 30.4 cm from application point in all treatments (Figs. 2-5, and Table 2). Demon TC (0.25% AI) plus Atlox 8916-TF (0.1% AI) and Demon WP plus G-3300 provided the maximum lateral distribution (53.2 cm) beneath the concrete slab with amounts adequate for termite control (Figs. 2 and 5). The EC formulation yielded higher vertical penetration of cypemethrin than WP formulations, however the amounts were not significantly different.

Table 2. Distribution of cypermethrin in sandy loam soil from the application point that is adequate for subterranean termite control (> 1.00 µg/g).

	Treatment			
Insecticide	AI +	Surfactant (0.1% AI)	Lateral[1] Distribution (cm)	Vertical[2] Penetration (cm)
1. Demon TC	0.25%	None	30.4	45.6
2. Demon TC	0.25%	Atlox 8916-TF	53.2	30.4
3. Demon TC	0.25%	G-3300	30.4	15.2
4. Demon TC	0.25%	Tween-20	45.6	45.6
5. Demon WP	0.25%	None	30.4	15.2
6. Demon WP	0.25%	Atlox 8916-TF	45.6	45.6
7. Demon WP	0.25%	G-3300	53.2	30.4
8. Demon WP	0.25%	Tween-20	38.0	30.4

[1]Distance from application point along soil core 1 located 2.5 cm directly below the concrete slab.
[2]Distance from the injection point in a vertical plane directly below the injection point.

Generally, Demon applied in combination with one of the three surfactants provided more lateral distribution directly below the concrete slab than when it is applied without a surfactant.

The location of each of the four cores (2.5, 15.6, 30.4, and 45.6 cm below the bottom of the slab) proved to be a significant factor for all treatments (Pr>F = 0.0001). This is reasonable since the largest residues were observed in core 1 in all treatments. Soil samples from cores 2-4 generally revealed less cypermethrin quantities with increasing depth. Significant differences in amounts were principally observed in first set of three soil samples measured in 7.6 cm increment from the application point.

Cypermethrin (Demon) applied using a sub-slab injection technique was detected at low mean concentrations at 45.6 cm soil depth. Based on these results, the authors believe that cypermethrin is placed near the soil injection point and the probability of it being present in non-target sites is minimal.

Data derived from this research have practical application in subterranean termite control. Commercial Pest Control Operators (PCOs) may increase lateral distribution of a termiticide beneath the concrete slab by using appropriate surfactant that has been previously tested with positive results.

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REFERENCES

Bennett, G. W., Ballee, D. L., Hall, R. C., Fahey, J. E., Butts, W. L., and Osmun, J. V. (1974). Persistence and distribution of chlordane and dieldrin applied as termiticides. *Bull. Environ.Contam. Toxicol.*, 11(1):64-69.

Brehm, W. L., (1991). Examining sub-slab injection. *Pest Control.*, February:32-33.

Davis, R. W., and Kamble, S. T. (1992). Distribution of sub-slab injected Dursban TC (chlorpyrifos) in a loamy sand soil when used for subterranean termite control. *Bull. Environ. Contam. Toxicol.*, 48:585-591.

Davis, R. W., and Kamble, S. T. (1993). Microencapsulated chlorpyrifos distribution in loamy sand and silty clay loam soils when applied with a sub-slab injector for subterranean termite control. *Bull. Environ. Contam. Toxicol.*, 50:458-465.

Kard, B. M., Mauldin, J. K., and Jones, S. C. (1989). Evaluation of soil termiticides for control of subterranean termites (Isoptera). *Sociobiology.*, 15:284-297.

Mampe, C.D. 1992. Rodding, soil type and application tips. *Pest Control.*, January:48-50.

SAS Institute., (1985). SAS users guide: statistics, *SAS Institute, Cary, N.C.*, version 5:433-506.

Su Nan-Yao, and R.H. Schefrahn, R. H., (1990). Comparison of eleven soil termiticides against the formosan subterranean termite and the eastern subterranean termite. *J. Econ. Entomol.*, 83(5):1918-1924.